
NASA-15626 (December 2003)
NATIONAL AERONAUTICS NASA
AND SPACE ADMINISTRATION Superseding NASA-15626
(June 2003)

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SECTION 15626

CENTRIFUGAL WATER CHILLERS
12/03

NOTE: Delete, revise, or add to the text in this
section to cover project requirements. Notes are
for designer information and will not appear in the
final project specification.

This section covers packaged self-contained hermetic
compressor units. Rewrite if unit is not
self-contained per definition.

Drawings or schedule shall include capacity,
capacity conditions, pressure drops, control
diagrams, and refrigerant used.

PART 1 GENERAL

1.1 REFERENCES

NOTE: The following references should not be
manually edited except to add new references.
References not used in the text will automatically
be deleted from this section of the project
specification.

The publications listed below form a part of this section to the extent
referenced:

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 480	(1987) Refrigerant-Cooled Liquid Coolers, Remote Type
ARI 520	(1997) Positive Displacement Refrigerant Compressors, Compressor Units and Condensing Units
ARI 550/590	(1998) Water-Chilling Packages Using the Vapor Compression Cycle

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
ENGINEERS (ASHRAE)

ASHRAE-Hdbk SE-SI (2000) Handbook, HVAC Systems and
Equipment (SI Edition)

ASME INTERNATIONAL (ASME)

ASME BPVC SEC VIII D1 (1998) Boiler and Pressure Vessel Code;
Section VIII, Pressure Vessels Division 1
- Basic Coverage

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1 (1986e) Mechanical Vibration - Balance
Quality Requirements of Rigid Rotors -
Part 1: Determination of Permissible
Residual Unbalance

NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA)

NEMA MG 1 (1998) Motors and Generators

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (1991) Enclosures for Electric Equipment
(1000 Volts Maximum)

U.S. DEPARTMENT OF ENERGY (DOE)

DOE CE-2 (2000) How to Buy an Energy-Efficient
Water-Cooled Electric Chiller

DOE CE-6 (2000) How to Buy an Energy-Efficient
Air-Cooled Electric Chiller

1.2 SUBMITTALS

**NOTE: Review submittal description (SD) definitions
in Section 01330 SUBMITTAL PROCEDURES and edit the
following list to reflect only the submittals
required for the project. Submittals should be kept
to the minimum required for adequate quality
control. Include a columnar list of appropriate
products and tests beneath each submittal
description.**

The following shall be submitted in accordance with Section 01330 SUBMITTAL
PROCEDURES in sufficient detail to show full compliance with the
specification:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists shall be submitted for centrifugal chiller systems in accordance with paragraph entitled, "General Requirements," of this section.

SD-02 Shop Drawings

Connection diagrams shall be submitted indicating the relations and connections of the following items. Drawings shall indicate the physical layout of all controls, and internal tubing and wiring details.

Centrifugal Water Chiller
Compressor
Condenser
Cooler
Purge System
Motors
Control and Control Panels

Control Diagrams shall be submitted for centrifugal chiller units in accordance with paragraph entitled, "General Requirements," of this section.

Installation drawings shall be submitted for centrifugal chiller systems in accordance with the paragraph entitled, "Installation," of this section. Drawings shall indicate overall physical features, dimensions, ratings, service requirements, and equipment weights.

As-Built Drawings shall be submitted for centrifugal chiller units in accordance with paragraph entitled, "General Requirements," of this section.

SD-03 Product Data

Equipment Foundation Data shall be submitted for the following items in accordance with paragraph entitled, "General Requirements," of this section.

Centrifugal Water Chiller
Compressor
Condenser
Cooler
Purge System
Motors

Equipment and Performance Data shall be submitted for centrifugal water chillers in accordance with paragraph entitled, "General Requirements," of this section.

Manufacturer's catalog data shall be submitted for the following items:

Centrifugal Water Chiller
Compressor
Condenser
Cooler
Purge System
Motors
Control and Control Panels
Insulation
Vibration Isolation
Special Tools
Spare Parts

SD-04 Samples

Manufacturer's Standard Color Chart shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-05 Design Data

Design Analysis and Calculations shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-06 Test Reports

Test reports for chiller units shall be submitted indicating the results of performance tests performed in accordance with the paragraph entitled, "Field Testing," of this section.

SD-07 Certificates

Listing of Product Installation shall be submitted for centrifugal chiller units in accordance with paragraph entitled, "Installation," of this section.

Certificates shall be submitted for following items showing conformance with the referenced standards contained in this section.

Centrifugal Water Chiller
Compressor
Condenser
Cooler
Purge System
Motors
Control and Control Panels
Insulation
Vibration Isolation
Special Tools
Spare Parts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals shall be submitted in accordance with paragraph entitled, "Manufacturer's Representative," of this section.

1.3 GENERAL REQUIREMENTS

NOTE: If Section 15003 GENERAL MECHANICAL PROVISIONS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted. If Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT is not included in the project specification, applicable requirements therefrom should be inserted and the second paragraph deleted. If Section 16225 MOTORS is not included in the project specification, applicable requirements therefrom should be inserted and the third paragraph deleted.

[Section 15003 GENERAL MECHANICAL PROVISIONS applies to work specified in this section.]

[Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT applies to work specified in this section.]

[Section 16225 MOTORS applies to this section.]

Control Diagrams shall be submitted for centrifugal chiller units showing the physical and functional relationship of equipment. Electrical diagrams shall show the size, type, and capacity of the system.

As-Built Drawings shall be submitted for centrifugal chiller units providing current factual information including deviations from, and amendments to, the drawings and concealed and visible changes in the work.

Material, Equipment, and Fixture Lists shall be submitted for centrifugal chiller systems including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Equipment and Performance Data shall be submitted for centrifugal water chillers indicating the guaranteed maximum brake power at 75-, 50-, 25-, and 10- percent points of full compressor capacity at design condenser water temperature. This information shall be developed from data specified herein.

Equipment Foundation Data shall be submitted including equipment weight and operating loads, location and projection of anchor bolts, and horizontal and vertical clearances for installation, operation, and maintenance. Data shall also include dimensions of foundations and relative elevations, and installation requirements such as noise abatement, vibration isolation, and utility services.

Manufacturer's Standard Color Chart shall indicate the manufacturer's standard color selections and finishes for chiller units.

Design Analysis and Calculations shall be submitted for centrifugal chillers indicating the manufacturer's recommended power ratings, rotational speeds, and piston speeds.

PART 2 PRODUCTS

NOTE: Pump and Motor balance shall conform to ISO 1940-1 - (1986) Balance Quality Requirements of Rigid Rotors - Determination of Permissible Residual Unbalance unless otherwise noted. Motor vibration levels shall conform to NEMA Specification MG-1, Motors and Generators, Part 7 unless otherwise noted.

NOTE: All rotating machinery shall be capable of having shaft alignment and machine balance following installation. This requirement shall include "skid-mounted" and "self-contained" units.

NOTE: Balance is the process of improving the mass distribution of the pump components in order to minimize damaging centrifugal forces. No component can be perfectly balanced. There will always be some remaining unbalance. The minimum recommended balance grade is ISO grade 2.5. Select an ISO grade or insert a standard.

2.1 CENTRIFUGAL WATER-CHILLER PACKAGE

Centrifugal water-chiller assembly shall be packaged and self-contained, and shall include compressor-condenser, cooler (refrigerant evaporator) accessories, control panel, and intercomponent piping and wiring ready for field-terminal connections.

Unit and spare parts shall conform to the applicable requirements of ARI 550/590, ARI 480, and specified requirements. Energy efficiency ratings shall meet or exceed the full-load efficiency and the integrated part-load value (IPLV) efficiency ratings as described in ARI 550/590 and the recommended levels specified in DOE CE-2 and DOE CE-6.

2.2 COMPRESSOR

NOTE: At higher than 3,600 rpm speeds, reevaluate 0.025 millimeter vibration limit. Do not use

compressor that will operate at 20,000 or higher rpm.

Compressor shall be [single] [multistage], [direct] [gear-driven] centrifugal type, with hermetically sealed, compressor-motor assembly. Motor windings shall be [refrigerant] [water-cooled]. Rotor assembly shall be statically and dynamically balanced to ISO 1940-1 -1986, [G6.3] [G2.5] [G1.0] [_____]. Shaft main bearings shall be replaceable sleeve-insert type.

Lubrication system shall be of the forced-feed type with oil sump, hermetically sealed motor-driven positive displacement pump, oil filter, and strainer. Oil temperature shall be thermostatically controlled. A mechanically operated oil supply shall be provided to the bearings during spin down in event of power interruption. A differential oil-pressure cutout shall be interlocked with starting equipment and shall allow the compressor to operate only when the required oil pressure is available at the bearings.

Compressor shall be provided with temperature-actuated capacity reduction and shall be of the multiple radial blade or butterfly-damper type Variable Frequency Drive (VFD) compressor motor control to provide automatic capacity regulation from 100 percent to 10 percent of capacity. Automatic hot-gas bypass shall be provided if required to maintain stable operation. Control system shall include automatic stopping, when load falls below 10 percent capacity point, and automatic unloaded restarting on load demand. Capacity modulation shall be controlled by the temperature of the water leaving the cooler. Unit controller shall be able to maintain leaving-water temperature at plus or minus 0.5 degree F 0.25 degrees C of the set point.

2.3 CONDENSER

Condenser shall be of the shell-and-tube cleanable-type construction. Condenser shall comply with ASHRAE-Hdbk SE-SI, Chapter 13, and ASME BPVC SEC VIII D1 regarding quality of materials used, methods of construction, design of components, and testing of materials, assemblies, connections, and appurtenances. Minimum water-side working pressure shall be 150 psig 1050 kilopascal, and minimum refrigerant-side working pressure shall be saturation pressure of refrigerant used at 85 degrees F 29 degrees C. Spaces not subject to ASME code due to size or other limitations shall be pneumatically tested at 1-1/2 times working pressure or 45 psig 310 kilopascal, whichever is greater.

Tubes shall be seamless copper tubing with integral fins and shall be individually removable from either end of shell. Tubes shall be rolled or brazed into tube sheet. Intermediate tube supports shall be provided so that distance between supports does not exceed approximately 3 feet 900 millimeter. Supports shall be fitted to the tubes in a manner that will preclude corrosion, vibration, and abrasion.

Water boxes or removable elbows shall be fitted and arranged to permit cleaning of tubes without disturbing piping beyond elbows. Elbows shall be flanged- or grooved-coupling type. End bells shall be hinged-mounted.

NOTE: R-12 is designated as a restricted material.
Use available substitutes as apply to specifier's
application. CFC's shall be phased out. No new
designs using CFC's allowed.

Unit shall be designed to permit pump-down and isolation of the entire
refrigerant charge within 80 percent of available condenser volume. If the
unit condenser does not have sufficient pump-down capacity, a separate
pump-out tank shall be provided.

NOTE: Many present-day nonchromate water treatment
chemicals degrade at temperatures as low as 100 to
135 degrees F 38 to 57 degrees C and tend to
severely foul heat-transfer surfaces. The
difference between a fouling factor of 0.0005 and
0.001 could approximate 7 percent of machine
capacity. Cost of unit with 0.001 fouling factor
will be higher and may be restrictive.

Limiting water velocity to 7 feet per second (fps) 2
meter per second could force selection of next
larger size machine.

Tube protectors are usually required at velocities
in excess of 7 fps 2 meter per second.

Select one of the following two paragraphs.
Normally, select the first paragraph.

Condenser performance shall be based on a maximum water velocity of 10 feet
per second (fps) 3 meter per second and a fouling factor of 0.001. Design
and construction provisions shall preclude tube failure due to erosion.

Condenser performance shall be based on a maximum water velocity of 7 fps 2
meter per second and a fouling factor of 0.001.

2.4 COOLER (REFRIGERANT EVAPORATOR)

Cooler shall conform to the requirements specified herein in paragraph
entitled, "Condenser," and the following:

Cooler capacity shall be based on refrigerant suction temperature in excess
of 32 degrees F 0 degrees C and a fouling factor of 0.0005.

A frangible safety relief device shall be provided. Device to be piped to
building exterior.

2.5 PURGE SYSTEM

**NOTE: R-11 and R-113 are restricted materials.
Purge system applies only to existing units and
modifications. An available substitute should be
found and incorporated immediately.**

When HCFC-123 refrigerant is used, a high efficiency purge system shall be provided and connected to the main refrigeration system. When in operation, the purge system shall function to automatically remove air, water vapor, and noncondensable gases from the refrigeration system and to condense, separate, and return to the system any refrigerant present therein. Purge system shall be manually or automatically started and stopped and shall be assembled as a compact unit. Purge system shall be complete with operating and safety devices and with an oil separator if recommended by the manufacturer. When a positive-pressure refrigerant is used by the manufacturer in the basic liquid chiller unit, a purge system will not be required. Units shall purge no more than 0.1 pounds 0.045 kg of non-condensibles.

2.6 CONTROL AND CONTROL PANELS

**NOTE: Select the following paragraph only after
checking control panel sizes and numbers to be sure
they can be unit mounted. Some or all starters may
be mounted in motor control center and unit will not
be totally self-contained.**

**Coordinate with Section 15902 CONTROL SYSTEMS and
electrical requirements.**

Water-chilling unit shall be provided with one or more control panels containing safety and operating devices and intercomponent piping and wiring for field terminal connection and fully automatic operation.

Controls shall be coordinated with automatic temperature controls systems and electrical work specified and indicated. Control panel shall contain control equipment specified, and control equipment normally furnished and recommended by the manufacturer for optimum operation of the system. Control panel items shall be permanently identified, including at least the following:

**NOTE: The following are manufacturer's standard
items. If the last two listed items, motor
controllers and NEMA 1 enclosures, are specified
elsewhere, delete from this paragraph.**

Refrigerant suction and discharge pressure gages

Oil-pressure gages

Purge-drum pressure gage

Refrigerant low-temperature or low-pressure cutout

Refrigerant high-pressure cutout

Time delay relays

Motor high-temperature cutout

Lubricating-oil high-temperature cutout if required by equipment

Oil differential-pressure interlock

Interlock relays and reset button

Manual/automatic selector switches and controls for purge pumps

Pilot lights indicating position of safety controls

System start/stop provisions with condition-indicating lights

Load-limiting device to operate capacity-control mechanism

Cooler refrigerant thermometer with well

Main circuit protective and interruptive device

Transformers for any other source-voltage requirements

Terminals for field-installed equipment

Motor controllers

NEMA 250, Type 1 enclosures

The following items shall be provided as part of the installation:

NOTE: Coordinate with drawings. Select, delete, or supplement. These are normally field-installed by the Contractor.

Audible-alarm bell, 4-inch 100 millimeter diameter

Chilled-water and condenser supply-and-return thermometers with wells

Indicating-type chilled-water thermostat with well

Chilled-water low-temperature cutout

2.7 MOTORS

Hermetically sealed motors shall conform to NEMA MG 1 ARI 520 and to requirements for motors as specified herein.

Bearings shall be [oil-lubricated, replaceable-sleeve, insertable type]
[permanently lubricated, rolling element type].

NOTE: Normally delete the following paragraph.
Review. Limit percent of full-load amperes at which
motor controller overload will trip (105 percent,
trane), gas pressure differential, pumps, sprays,
unit capacity, or other. Coordinate with motor
controller specification and drawings.

Motor shall have two manually resettable thermal-overload protective devices located within windings.

NOTE: Coordinate the following with the following
motor controller specification and drawings.
Rewrite as necessary to suit designed size and type
equipment.

If water-chilled unit or any component could be damaged by reverse motor operation, and when proposed water-chiller unit contains a mechanically driven lubricating-oil pump, the manufacturer's responsibility shall include:

Providing reverse-phase rotation protection, if motor controllers are provided as part of package

Indicating in shop drawings that reverse-phase rotation protection is necessary if motor controllers are in a motor-control center not provided by the manufacturer

2.8 INSULATION

NOTE: Select the following paragraphs only when
specified equipment is to be provided with factory
insulation. Normally provide for field insulation
of cooler headers.

Cooler shell and suction piping between evaporator and first stage of each compressor unit shall be insulated and vapor-sealed. Water boxes shall be insulated to provide for ease of access to heads for inspection and repair. Where motors are the gas-cooled type, insulation and vapor seal shall be provided on the cold-gas inlet connection to the motor.

Vapor-seal material shall be manufacturer's standard color elastomeric unicellular foam of 1 inch 25 millimeter minimum thickness to preclude condensation of ambient moisture on any surface under site-operating conditions. If unicellular material is black or is otherwise coated, only polyvinylchloride lacquer shall be used for coating. Any coating that cracks when unicellular material is compressed shall be removed and replaced with specified coating at no additional expense to the Government.

2.9 VIBRATION ISOLATION

Vibration isolation provisions shall conform to requirements specified in Section 15072 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT.

2.10 SPECIAL TOOLS

One complete set of special tools, as recommended by the manufacturer, shall be provided for field maintenance of the system. Tools shall be contained in a locked toolbox. Two keys shall be provided to the Contracting Officer.

PART 3 EXECUTION

3.1 INSTALLATION

Equipment shall be installed as specified, and in accordance with manufacturer's recommendations.

Listing of Product Installation shall be submitted for centrifugal chiller units showing at least 5 installed units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

3.2 MANUFACTURER'S REPRESENTATIVE

Services of a competent factory-trained representative shall be provided to supervise the assembly, charging, testing, and startup of equipment; in addition, Government personnel shall receive 8 hours of instructions in proper operation and maintenance procedures. A factory performance test will be conducted on every chiller in accordance with ARI 550/590. Test will be witnessed by Government and Contractor.

Contractor shall submit [6] [_____] copies of the Operation and Maintenance Manuals 30 calendar days prior to testing the centrifugal chiller system. Data shall be updated and resubmitted for final approval no later than 30 calendar days prior to contract completion.

3.3 REFRIGERANT AND OIL CHARGE

Unit(s) shall be completely charged with refrigerant and oil before operation.

3.4 ALIGNMENT

Before attempting alignment, the contractor will demonstrate that the pump does not have any load/force imposed by the piping system. Minimum alignment values (below) are for pump and driver at normal running temperatures. Values must be compensated for thermal growth. Limited movement of the pump or driver (commonly known as bolt-bound) must be corrected to ensure alignment capability. Hold down bolts shall not be undercut in order to perform adjustment.

Shims shall be commercially die-cut, without seams or folds, and be made of corrosion resistant stainless steel. No more than four shims shall be used at any single point.

Units with drive motor over [7.5][10][15][20][25] hp shall have alignment jack bolts installed.

Pump and driver may have an intermediate shaft, spacer, or spool piece (sometimes called a jackshaft) Based on the motor nominal operating speed, the Pump and driver shall be aligned to the following minimum specifications:

Speed(RPM)	Close-Coupled Offset (mils)	Close-Coupled Angle(mils/in.)	Spool Piece Angle (mils/in. @ coupling pt.)
600	6.0	2.0	3.0
900	5.0	1.5	2.0
1200	4.0	1.0	1.5
1800	3.0	0.5	1.0
3600	1.5	0.4	0.5
7200	1.0	0.3	0.4

Pump alignment shall be performed under the direction of the manufacturer's representative.

Final alignment settings shall be provided as part of the final test data.

3.5 FIELD TESTING

Prior to final acceptance, vibration analysis shall verify pump and motor conformance to specifications. Vibration levels shall not be more than .075 in/sec at 1 times run speed and at pump frequency, and .04 in/sec at other multiples of run speed.

Contractor shall use an Fast Fourier Transformer (FFT) analyzer to measure vibration levels. It shall have the following characteristics: A dynamic range greater than 70 dB; a minimum of 400 line resolution; a frequency response range of 5 Hz-10 KHz(300-600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of + or - 20% or+ or - 1.5 dB. An accelerometer, either stud-mounted or mounted using a rare earth, low mass magnet and sound disk(or finished surface) shall be used with the FFT analyzer to collect data. The mass of the accelerometer and its mounting shall have minimal

influence on the frequency response of the system over the selected measurement range.

Upon completion of the installation, and within 60 calendar days after the date of initial operation, performance tests shall be conducted in the presence of the Contracting Officer. These tests shall be conducted until the performance of the system is proven, with 8 hours of successful operation as a minimum period. Any equipment defects or performance deficiencies shall be corrected, and the tests repeated until performance is fully satisfactory. Water flows shall be determined from pressure-drop across chiller and condenser, and from pump curves. Calibrated test instruments shall be provided. Government will provide load.

Each unit shall be tested for leaks under pressure and shall be evacuated and dehydrated to 35 degrees F 2 degrees C wet bulb, or an absolute pressure of not over 0.24 inch of mercury 813 pascal.

Final test reports shall be provided to the Contracting Officer. Reports shall have a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --